Armstrong on Frequency Modulation

Introduced by JAMES E. BRITTAIN

EDITORIAL COMMENTARY

In this classic paper presented at an IRE meeting in New York City in November 1935, Edwin H. Armstrong challenged the conventional wisdom that frequency modulation inherently was inferior to amplitude modulation in radio communication. He reported that he and several assistants at the Hartley Laboratory at Columbia University had worked for several years to perfect the new broadcasting system. Armstrong discussed the several conditions that had to be satisfied in order to make the performance superior to the existing AM system. He acknowledged that the technical features of the transmitter and receiver might seem too complicated to encourage widespread usage despite the great improvement in fidelity and signal-to-noise ratio, but argued that "The complexity is merely that of design, not of operation." He concluded that it was now feasible to provide an FM broadcasting service that would be "very greatly superior" to that of existing AM stations.

BIOGRAPHICAL SKETCH

Edwin H. Armstrong (1890–1954) was born in New York City and graduated in electrical engineering from Columbia University in 1913. He invented the regenerative feedback triode oscillator while still an undergraduate at Columbia although his priority was challenged by Lee de Forest and the invention became the subject of protracted litigation. Armstrong's technical papers on vacuum tube amplifiers and oscillators published in 1914 and 1915 were highly regarded by the young engineers who were attracted to the rapidly expanding field of radio-electronics. He was elected as president of the Radio Club of America in 1916 and was awarded the first IRE Medal of Honor in 1918. During the first World War, he served as an officer in the Army Signal Corps in France where he conceived his second major invention, the superheterodyne radio receiver. He returned to Columbia University in 1919 and presented an IRE paper on the superheterodyne receiver in December 1919. Armstrong received substantial financial benefits from the sale of patent rights to the new receiver and to the superregenerative receiver that he invented in 1921. His paper on superregeneration given at an IRE meeting in June 1922 attracted what was reported to be the largest audience that ever had attended a meeting of the Institute.

Armstrong next turned his attention to the problem of radio interference and found an attractive solution in the form of a frequency modulation system that he patented in 1933. He disclosed the characteristics and advantages of FM in an IRE paper presented in November 1935. After failing to interest the Radio Corporation of America in the new system, he undertook to promote it himself but encountered difficulties that he blamed on "vested interests, habits, customs and legislation." He installed an FM transmitter in Alpine, NJ, and began regular broadcasts in 1939. In a paper published in 1940, Armstrong compared the competition between AM and FM to the battle between ac and dc power systems during the late nineteenth century. He received the Franklin Medal of the Franklin Institute in 1941 and the Edison Medal from the AIEE in 1943. During the war years he helped to develop FM communication systems for military communication including two-way systems for Army tanks. His final years brought increasing frustration because of patent litigation and rulings by the Federal Communication Commission that delayed the spread of FM broadcasting. For further information, see Lawrence Lessing, *Man of High Fidelity: Edwin Howard Armstrong* (Bantam, 1969); *Dictionary of Scientific Biography*, vol. 1, pp. 287–288; an obituary in *Electrical Engineering*, vol. 73, p. 283, 1954. A collection of Armstrong's personal and professional papers consisting of approximately 200 000 items is located at the Butler Library at Columbia University.

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